OXYGEN IN ITS RELATION TO MINERALOGY.

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OXYGEN is a simple word, but it has a wide relation. It is the name of the most important element in all of nature's operations. It is, like the air, transparent, and without color, odor, or taste. It is the most abundant of all substances. It makes nearly one-half of the entire bulk of material substances in and of our earth. It constitutes by weight nearly one-fifth of the atmosphere, eight-ninths of the waters of the earth, and about one-third of the earth's solid mass.

It enters into combination with all the elements that make the natural substance of this world, and probably all worlds—for it is generally accepted that this world, though so small an atom, is an epitome of the universe.

In the mineral kingdom especially is it associated with all the elements. Its wide range of association makes it the most interesting element in the mineral kingdom.

The chemist tells us that there is but one element with which oxygen does not combine, and that is chlorine. This is not the case with any other of the elements. That is, it does not unite with chlorine singly or alone, but it enters into combinations with other minerals that are attached to chlorine; for instance, potassium chlorate, which is one of the common substances from which oxygen is obtained. The potassium chlorate is composed of three elements—the two gases, oxygen and chlorine, and the metal potassium, in the proportion of one atom each of potassium and chlorine and three atoms of oxygen. The oxygen is driven off by heat, and the chlorine remains with the potassium, leaving what is called potassium chloride.

We have a practical illustration here of the lack of affinity with chlorine. The potassium is satisfied in its affections with the chlorine, and freely lets go of the oxygen under the persuasion of a little heat. Indeed, it gives it up so freely that there is some danger of explosion in obtaining oxygen from potassium chlorate alone—the oxygen being so ready to leave, I suppose, in consequence of its dislike to chlorine, that large quantities of the gas are apt to be set free suddenly. This danger is prevented by mixing it with an equal weight of manganese dioxide.

PLATE IV.—Kansas Academy of Science Museum, 1905 (looking east)—Capitol Building, Topeka.

What is very singular in this whole proceeding is that the oxygen has a very strong affection for the manganese, and consequently the manganese does not give up any of its oxygen under the persuasion of heat alone. It only acts as a restraining force to make the oxygen leave the potassium in a quiet and orderly manner and not violently and in anger, as it would be likely to do.

We have seen how indifferently potassium lets oxygen go away when it has chlorine for a companion. Let us, for an illustration, observe how potassium behaves with oxygen when all the company is congenial.

Take, for instance, potassium carbonate, which is composed of two parts of potassium, one of carbon, and three of oxygen. Here the affection of the potassium for the oxygen is so strong that the metal potassium must be heated until it becomes a vapor before it will consent to part with the oxygen.

If we conduct proper experiments with these apparently inert and indifferent substances and observe carefully their action, we will come to the conclusion that there are affectionate attachments between minerals as well as between human beings and animals.

This element, like all elements, has its individual affections. It apparently does not love all alike.

With the metals it unites in varying combinations. These combinations are as fixed in nature's operations as our idea of the laws of the Medes and Persians.

With some metals it always divides fair, one atom of oxygen to one atom of metal. It is then known as a monoxide or one oxide.

With some metals it is a little more generous, and will put into the business two atoms of oxygen to one of the metal. This firm is called a dioxide, or two oxides.

Then with some metals it is lavish in its generosity, and will put in three atoms, or shares, to one of the metal; and this partnership is known as a trioxide, or three oxides. The prefixes mono, di, tri, are derived from Greek words, meaning one, two, three.

Then there are some metals with which it goes into partnership on the basis of one and a half to one; but, as there are no half atoms in nature, it gets around the difficulty by putting in three atoms of oxygen as a sesquioxide, the Latin prefix *sesqui* meaning one and a half. This is the common combination with iron. The most abundant ores of iron are sesquioxide. There are two other oxides of iron—one, the monoxide, which is not of so much importance, and the magnetic oxide, which has three atoms of iron to four atoms of oxygen. But I will not afflict you with the technical properties of this element. This knowledge you can secure more completely and in a more satisfactory manner from chemistries and encyclopedias.

While oxygen is one of the chief components of all vegetable and animal substances, and its work in the animal kingdom is absorbingly interesting, I wish at this time to attract your attention more particularly to its special importance in the mineral kingdom. However, it would be well to bear in mind that everything on the earth, and of the earth, and about the earth, is mineral. The air we breathe, the food we eat, the clothes we wear, every article in use by man, our bodies, every living and inanimate thing, are made up of mineral elements and are resolvable into mineral elements.

We might justly call oxygen the Ariel among the elements, marshaling its fairy hosts at will in every conceivable parade of beautiful crystalline forms and colors. Its combinations with the metals gives the coloring matter that tints all the beautiful varieties of minerals, as well as all the brilliant and varied colors of the flowers and the vegetable kingdom.

Its combinations with silicon, calcium and potassium make it practically the most important constituent of all rocks. The primal granites, all the igneous and metamorphic rocks, all of the felsites, quartzites, the sandstones, the shales and limestones, owe their hardness, their durability and their existence to this fairy, airy element, light and colorless as the air.

Nearly all the beautiful crystallizations of every variety of form and color that make up the gems of the earth are the affectionate and obedient subjects of this master element. With varying proportions of silicon and other elements it makes the hard, durable granites, quartzites, diorites, trachytes, rhyolites, as well as the sandstones and softer shales. Associated with carbon it unites with calcium, and makes the limestones in all their variety, from the coarse, argillaceous, magnesian limes to the perfectly crystallized white and colored marbles and the brilliant, transparent calcites.

One of the most remarkable illustrations of its fancy is exhibited in its union with the soft, white element aluminum, making alumina, more commonly known as corundum, or emery, the mineral next in hardness to the diamond; and when it is found pure and transparent it makes the most valuable and most beautiful gems of the earth — the ruby, the sapphire, and the emerald. These gems, when pure, are simple oxides of aluminum, colored with the presence of a metallic oxide so small in quantity that the skill of the chemist cannot measure it.

Oxygen is the life-giving and sustaining element; the active principle of combustion; the heart of fire. Life cannot exist in the animal kingdom but a few moments without it.

While it is the life builder and the life-sustaining force in nature, yet, strange contrariety, immediately upon the cessation of life its

special work is to tear the dead carcass to pieces and liberate the elements of which it is composed, so that they may again become industrial activities in the laboratory of nature.

In the animal and vegetable kingdoms we can witness the ceaseless activity of oxygen in building up while there is life, and its destructive force in tearing to pieces when life has ceased. But in the so-called mineral kingdom the processes are so slow, to our finite observation, that they are not so apparent. Yet oxygen is at work upon the dead rocks, and, in the language of the poet, "the ceaseless tooth of time" is constantly at work tearing the dead rocks to pieces and liberating their elements for renewed activity.

I want to take the liberty of availing myself of the opportunity in this gathering of active educational workers to ask them to give more attention to the teaching and study of mineralogy in our schools than they have been in the practice of doing.

The world is waking up to a better comprehension of the vast and useful field of mineralogy. How intimately it concerns all the necessities of man. Chemistry is wholly dependent upon it. It would have no material to work upon without it. Medicine is dependent upon it for all its remedies to heal the sick. All the industries that mark the progress of man and help him to a better enjoyment of life are dependent upon the materials of this useful kingdom.

The industries are to-day taxing the best skill of the chemist to study out new combinations of mineral elements to meet their growing wants. The mineral industry of this country is giving active and profitable employment to about one one-hundredth of the entire population of the country, counting men, women, and children. Its product is nearly equal in money value to all the other products of the fields. It is calling for the best educated skill to meet its growing wants. Its rewards for intelligent and skilful labor equal any line of industrial work giving employment to man.

The subject is constantly widening. Students of sciences are only beginning to comprehend its far-reaching possibilities. "Nearer, my God, to Thee" is a sweet song, but nowhere in nature do we get nearer to the creator of all things than in the study of mineralogy, with its wonderful variety of forms, and its gems of infinite beauty.

A new field is opening to it. The necessity of minerals to the existence of life are set forth in a paper, "The Predominant Rule of Mineral Substances in Biological Phenomena," by M. Herrera, in Revue Scientifique. He says:

"Science made a great step when she succeeded in obtaining imitations of protoplasm, whose structure has once been looked upon as an almost supernatural phenomenon. But the progress was still greater when she succeeded in preparing perfect imitations of or-

ganic bodies with inorganic material, such as calcium chlorid, sodium phosphate, and calcium carbonate—substances that are found everywhere. Beside, the structure of living beings, whether organic or inorganic, would be useless without the water and salts to determine the tonus and the nutritive osmotic currents.

"Although substances from the organic kingdom are sufficient in themselves for the support of life, it is because they always contain a certain proportion of mineral matter.

"We cannot deny the importance of the 600 organic substances extracted from plants, but neither can we deny that living beings proceed out of inorganic forces and substances. If my views are correct, living beings must be regarded as mineral colloids, and zoology and botany as chapters of mineralogy."

M. Herrera should have gone farther; instead of saying, "it is because they always contain a certain proportion of mineral matter," he should have said, "it is because they are wholly made up of mineral matter."

I know of but two colleges in this country that give distinctive prominence to mineralogy in their work. Those are Yale College and Columbia College. Yale College owes a large part of its fame to having had a Dana conspicuously connected with it. James A. Dana has left an imperishable monument to commemorate his memory in his "System of Mineralogy," which is now the recognized authority on mineralogy in the English language; and I am told by those who are familiar with other languages that there is no work in existence that covers the field so completely. A worthy son is following in his father's footsteps and carrying on the work.

The rapid development of our mineral resources and the proud position our country has attained in mineral production, giving evidence of possessing mineral resources far surpassing any other equal area on the globe, should arouse us to the importance of giving more attention to the study of mineralogy.

As mineralogy practically covers the useful field of geology, and it is more essentially the science of to-day and of the future, it should be made the leading branch of natural-science instruction in our educational institutions.

Mineralogy is the natural handmaid of geology. In studying the composition of the matter that makes up the crust of the earth, to learn its useful properties for man's comfort and progress, the student of mineralogy necessarily has to learn the practical part of geology; the natural relative position of the primary rocks; the history, position, composition and useful properties of the sedimentary rocks; the phenomena and result of igneous action, and its metamorphic results in affecting the deposition of the useful minerals. This wide

field in mineralogy takes in a good deal of what is useful in geology; and considering the practical utility of mineralogy, what an important factor it has been, is and will be for all time in civilized progress, it does seem to me that our educators would make themselves more useful if they would give more attention to this live, practical science. Take a little time off from their devotion to the Silurian, Devonian and Carboniferous ages, and get acquainted with the home habits of gold, silver, iron, lead, zinc, aluminum, silicon, carbon, sulphur, sodium, potassium, etc., and try to catch up with the twentieth century that now, like a great globe of light, is lifting its disk above the horizon to light us on to a future of wonderful possibilities.